surface of the target element **228** and produce x-rays. In one embodiment of the invention, a Nd:YAG laser was coupled into a SiO2 optical fiber having a diameter of 400 microns. A 20 kV power supply was used, and a thermionic cathode made of tungsten was used. Even with a disc-shaped, planar cathode, only a few watts of power was needed to generate over 100 μA of electron current. In another example, an infrared diode laser was used in conjunction with a spiral-shaped, half millimeter etched cathode, to achieve about 100 μA of electron current with only 180 mW of power, thereby substantially reducing the power requirements for the apparatus **200**.

FIGS. **3**(*a*) and **3**(*b*) illustrate in more detail a spiral-shaped cathode **300** constructed in accordance with the present invention. FIG. **3**(*a*) illustrates a planar view of the spiral-shaped cathode **300**, whereas FIG. **3**(*b*) illustrates a side view. In a preferred embodiment, the spiral-shaped cathode **300** may be fabricated by using photoetching techniques known in the art. The spiral-shaped cathode **300** includes a conductive element **310** arranged in a spiral shape. The material forming the spiral-shaped conductive element is preferably a high melting point metal adapted to withstand high temperature uses. Suitable materials forming the cathode may include tungsten, thoriated tungsten, other tungsten alloys, tantalum, rhenium, thoriated rhenium, and molybdenum. Preferably, the spiral-shaped conductive element **310** forms a planar coil, although other forms of conductive coils may be used, such as helical coils. Spiral coils of various shapes can be used. For example, each of the plurality of spaced apart turns may have a substantially circular shape, when viewed from the longitudinal direction. Alternatively, the spiral coil may have other transverse sectional shapes, such as oval, square, or rectangular.

The spiral-shaped conductive element **310** has a plurality of spaced apart turns, which define an interstitial spacing **330** between each successive turn. The conductive element **310** may have a length of about 2 mm to about 7 mm, although other dimensions are also within the scope of this invention. The distance between adjacent turns of the conductive element **310** may be about 25 microns to about 50 microns, although other dimensions are also within the scope of this invention. Since the spiral-shaped cathode **300** is disposed within the vacuum within the capsule **230** (shown in FIGS. **2**(*a*) and **2**(*b*)), heat transfer across the interstitial spacing **330** between adjacent turns of the conductive element **310** is essentially eliminated. In this way, heat loss in the thermionic cathode **300** that is caused by thermal conduction is substantially reduced.

In an exemplary embodiment, the spiral-shaped thermionic cathode **300** was fabricated using a conductive wire 0.002 mm thick, and 7.4 mm long. In this embodiment, the conductive wire defined two spaced-apart turns. The power loss caused by thermal conduction was only 0.126 Watts, as compared to planar, disk-shaped cathodes, in which the power loss due to thermal conduction was about 1.1 Watts. The power loss caused by thermal radiation was about 140 mW.

While the invention has been particularly shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A therapeutic radiation source, comprising:

A. a radiation generator assembly, comprising:

a. an electron source for emitting electrons to generate an electron beam along a beam path, said electron source including a thermionic cathode having an electron emissive surface, and

b. a target positioned in said beam path, said target including means for emitting therapeutic radiation in response to incident accelerated electrons from said electron beam; wherein said thermionic cathode comprises a spiral-shaped conductive element;

B. a source of optical radiation; and

C. optical delivery structure having an originating end and a terminating end and adapted for transmitting to said terminating end optical radiation generated by said source and incident on said originating end; and wherein said optical delivery structure are adapted for directing a beam of said transmitted optical radiation upon a surface of said thermionic cathode; and wherein said beam of optical radiation has a power level sufficient to heat at least a portion of said surface to an electron emitting temperature so as to cause thermionic emission of electrons from said surface.

2. A therapeutic radiation source according to claim **1**, further comprising:

a substantially rigid housing enclosing said thermionic cathode and said target, wherein said housing defines a substantially evacuated interior region extending along said beam path between a proximal end and a distal end of said housing.

3. A therapeutic radiation source according to claim **1**, wherein said thermionic cathode is disposed at said input end of said housing.

4. A therapeutic radiation source according to claim **1**, further comprising a radiation transmissive window at an output end of said housing, wherein therapeutic radiation emitted from said target is directed through said radiation transmissive window.

5. A therapeutic radiation source according to claim **1**, wherein said spiral-shaped conductive element defines a plurality of spaced apart turns.

6. A therapeutic radiation source according to claim **5**, wherein said conductive element defines an interstitial space between each successive turn.

7. A therapeutic radiation source according to claim **5**, wherein said spiral-shaped conductive element forms a planar coil.

8. A therapeutic radiation source according to claim **5**, wherein said spiral-shaped conductive element forms a helical coil.

9. A therapeutic radiation source according to claim **5**, wherein the distance between adjacent turns of said conductive coil is from about 25 microns to about 50 microns.

10. A therapeutic radiation source according to claim **5**, wherein each of said plurality of spaced apart turns has a transverse sectional shape that is substantially circular.

11. A therapeutic radiation source according to claim **1**, wherein said optical delivery structure comprises a fiber optical cable.

12. A therapeutic radiation source according to claim **1**, wherein said fiber optical cable has a diameter between about 100 microns to about 200 microns.

13. A therapeutic radiation source according to claim **5**, wherein said spiral-shaped conductive coil has a length between about 2 mm to about 7 mm.

14. A therapeutic radiation source according to claim **1**, wherein the power required for heating said electron emissive surface of said cathode so as to generate an electron beam forming a current of about 2 micro amps is between about 0.1 Watt to about 1.0 Watt.

15. A therapeutic radiation source according to claim **1**, wherein said optical source is a laser, and wherein said beam of optical radiation is substantially monochromatic and coherent.

16. A therapeutic radiation source according to claim **1**, wherein said therapeutic radiation comprises x-rays.

17. A therapeutic radiation source according to claim **1**, wherein power loss caused by thermal conduction is less than 0.2 Watts.

18. A therapeutic radiation source according to claim **17**, wherein heat transfer across the spacing between each adjacent turn of said conductive element is essentially eliminated, thereby substantially reducing in said thermionic cathode heat loss caused by thermal conduction.

19. A therapeutic radiation source according to claim **1**, further including means for establishing an accelerating electric field which acts to accelerate electrons emitted from said electron source toward said target.

20. A therapeutic radiation source according to claim **19**, wherein said means for establishing an accelerating electric field is a power supply.

21. A therapeutic radiation source, comprising:

A. a radiation generator assembly, comprising:

a. an electron source for emitting electrons to generate an electron beam along a beam path, said electron source including a thermionic cathode having an electron emissive surface, and

b. a target positioned in said beam path, said target including means for emitting therapeutic radiation in response to incident accelerated electrons from said electron beam; and

c. a substantially rigid housing enclosing said thermionic cathode and said target, wherein said housing defines a substantially evacuated interior region extending along said beam path between an input end and an output end of said housing.

B. a source of optical radiation; and

C. optical delivery structure having an originating end and a terminating end and adapted for transmitting to said terminating end optical radiation generated by said source and incident on said originating end, said optical delivery structure being adapted for directing a beam of said transmitted optical radiation upon a surface of said thermionic cathode,

wherein said beam of optical radiation has a power level sufficient to heat at least a portion of said surface to an electron emitting temperature so as to cause thermionic emission of electrons from said surface; and

wherein said thermionic cathode comprises a spiral-shaped conductive element having a plurality of spaced apart turns.

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14. A therapeutic radiation source according to claim 1, wherein the power required for heating said electron emissive surface of said cathode so as to generate an electron beam forming a current of about 2 micro amps is between about 0.1 Watt to about 1.0 Watt.

15. A therapeutic radiation source according to claim 1, wherein said optical source is a laser, and wherein said beam of optical radiation is substantially monochromatic and coherent.

16. A therapeutic radiation source according to claim 1, wherein said therapeutic radiation comprises x-rays.

17. A therapeutic radiation source according to claim 1, wherein power loss caused by thermal conduction is less than 0.2 Watts.

18. A therapeutic radiation source according to claim 17, wherein heat transfer across the spacing between each adjacent turn of said conductive element is essentially eliminated, thereby substantially reducing in said thermionic cathode heat loss caused by thermal conduction.

19. A therapeutic radiation source according to claim 1, further including means for establishing an accelerating electric field which acts to accelerate electrons emitted from said electron source toward said target.

20. A therapeutic radiation source according to claim 19, wherein said means for establishing an accelerating electric field is a power supply.

21. A therapeutic radiation source, comprising:

A. a radiation generator assembly, comprising:

a. an electron source for emitting electrons to generate an electron beam along a beam path, said electron source including a thermionic cathode having an electron emissive surface, and

b. a target positioned in said beam path, said target including means for emitting therapeutic radiation in response to incident accelerated electrons from said electron beam; and

c. a substantially rigid housing enclosing said thermionic cathode and said target, wherein said housing defines a substantially evacuated interior region extending along said beam path between an input end and an output end of said housing.

B. a source of optical radiation; and

C. optical delivery structure having an originating end and a terminating end and adapted for transmitting to said terminating end optical radiation generated by said source and incident on said originating end, said optical delivery structure being adapted for directing a beam of said transmitted optical radiation upon a surface of said thermionic cathode,

wherein said beam of optical radiation has a power level sufficient to heat at least a portion of said surface to an electron emitting temperature so as to cause thermionic emission of electrons from said surface; and

wherein said thermionic cathode comprises a spiral-shaped conductive element having a plurality of spaced apart turns.

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